TURBULENCE CHARACTERISTICS OF A SWIRLING JET

APPLICATION NOTE LDV-007

Swirling jets present an interesting flow pattern for practical and theoretical standpoints. Practically they appear in aircraft combustors and residential/commercial burners where swirl helps improve mixing and stabilizes the flame. Lean combustion can be utilized more efficiently with swirl-generated turbulence; otherwise the flame speed becomes too low and burn-out occurs. Effects of the addition of swirl to a jet flow on its turbulence characteristics are still not completely understood. Thermal anemometry could be used to study this type of flow, due to its high frequency response capabilities, but as a non-intrusive technique, laser Doppler velocimetry (LDV) would be a better alternative.

A three-component LDV system (as shown in Fig. 1) was used with a XYZ traverse system to perform a full survey of a turbulent jet with various amounts of swirl. The system was composed of a 5W Ar ion laser for maximum date rate in all 3 components, FBL-3 fiberlight™ beam generator, and TR260 & TR160 transceiver probes. The probe-to-probe angle was 90 degrees, and both probes were positioned at about 45 degrees with respect to the jet axis. Signals were captured by the transceiver probes and sent to a PDM1000-3 detector module. An FSA 3500-3 signal processor and FLOWSIZER™ software were used to analyze the data. A full description of these components can be found in the Size and Velocity Measurement Systems brochure, available on www.tsi.com.

Figure 1: Three component LDV system using 2 transceiver probes for maximum flexibility and maximum resolution of on-axis resolution.

Figure 2 shows one component of the Reynolds stress tensor for a swirling jet flow, at a swirl ratio of 0.21 and Reynolds number of 107,000. As the swirl ratio was increased, the jet diameter increased at a given distance downstream. Sufficient data were taken at each measurement point to achieve a maximum of 1% uncertainty in the second moments. Careful measurement of the positioning of the probes with respect to the nozzle device was required to minimize errors in magnitude and symmetry of the data. Results obtained showed very good consistency and minimal scatter. The swirl number was found to have a major effect on the downstream Reynolds stress evolution, with higher swirl numbers collapsing the second order variables sooner. More swirl also caused the jet to grow more rapidly in width, even without a significant tangential velocity component.

The above results illustrate some of the turbulence measurements and analysis one can perform with data obtained using a TSI three-component LDV system. Data presented here are courtesy of Prof. J. Naughton and R. Semaan, Dept. of Mechanical Engineering, Univ. Wyoming. For further details, please refer to AIAA Paper 2008-761.

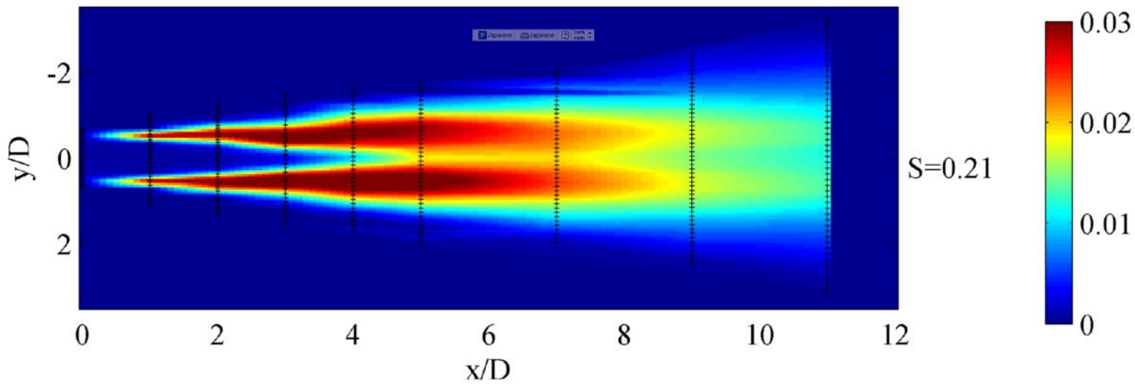

Figure 2: Measured u'u' Reynolds stress normalized by the exit axial velocity in the swirling jet with swirl ratio at 0.21.
Courtesy: Prof. J. Naughton and R. Semaan, Dept. of Mech. Engineering, Univ. Wyoming.

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